Space Weather Technical Forecast

Issued on Tuesday, 23 July 2024 at 13:10 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: Slight Chance of G1 today. G2 Likely UTC day of Wednesday 24 July, Chance G3. R1 Likely throughout.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Activity as measured at GOES16 was Moderate, with a peak flare of M1.5 at 22/1300 UTC, which originated from Ex-3744, now located just beyond the west limb.

There are currently up to nine regions on the solar disc, with AR3764 and AR3763 both rotating onto the eastern solar horizon in the period as AR3744 departed over the west limb. Only slow and modest changes were observed in the past 24 hours, with AR3761 showing slight penumbral growth in its leading group, similar with AR3762 to the east. AR3751 by contrast showed a fading tendency in its trailing portion, as did AR3759 to its west.

There was a narrowly far-sided event from the southeastern limb that dominated coronagraph imagery during the UTC evening. This feature plays no part in the forecast. This was shortly followed by a very large full halo CME from the far-side of the Sun, which produced the current and on-going minor (S1) proton storm event. Another CME was observed at 23/0400 UTC off the southwest limb, which was associated with C3 flare, which has been analysed for any potential Earth-directed components - pending results. Otherwise, no new Earth-directed were observed in coronagraph imagery in the past 24 hours.

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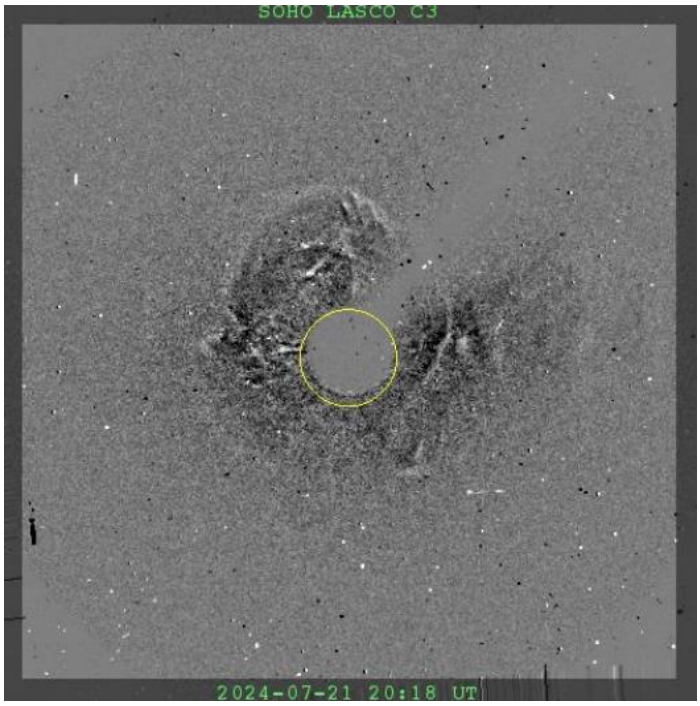
Figure 0: Lasco C3 difference imagery of the 21 July filament lift-off CME from the vicinity of AR3757, showing a north-shifted full halo. This feature is due to reach Earth during the early hours UTC of 24 July.



Solar Wind / Geomagnetic Activity: The solar wind, as measured by ACE at L1, showed a continuation of a slow regime, albeit with an unusually stable and anti-aligned (with Earth's field) Bz component (between -7 and +6nT), with the IMF showing a gradual rise to become Slightly Elevated, peaking at 10nT around 22/1730UTC. The solar wind speed was more subdued in oscillating about 280-300km/s, while the solar wind density was within single figures ppcc throughout. The phi angle was mostly away from the Sun (positive) throughout.

The net result of the above solar wind measures was for mostly Quiet (Kp0-2) geomagnetic indices, with an Unsettled (Kp3) interval observed 22/1800-2100UTC.

Energetic Particles / Solar Radiation: High energy (greater than 10 MeV) proton flux observed by GOES18 showed a rapid rise in proton levels from 22/0100 UTC due to a large full halo CME from the far-side of the Sun, which resulted in both the 10MeV and 100MeV threshold being reached. The S1 event is currently on-going. High energy electron flux (greater than 2MeV) observed at GOES16 was at Normal Background. The 24-hour fluence was well below Active, with 9.57e5 integrated pfu observed at 23/0001UTC.

Four-Day Space Weather Forecast Summary

Solar Activity: Moderate activity is Likely throughout. While Ex-AR3744 has now departed the disc, its loss is in some way compensated for by the flaring into life of AR3762 in the southeastern disc.

Solar Wind /Geomagnetic Activity: No fast winds feature in the forecast period. Two CMEs are expected - the first from a filament eruption that left the Sun on 19 July which is due inside the first 24 hours - although there is currently no evidence in solar wind data of its arrival, if it does arrive, it may give Unsettled or Active intervals, with slight chance of G1.

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Secondly, a full-halo CME that left the Sun on 21 July from the immediate east of AR3757 is due in the early hours of 24 July. This is Likely to give G2 conditions, with a Chance of G3 in the UTC day of 24 July. A gradual decline to Quiet geomagnetic activity is then expected into the second half of the UTC working week, barring new CMEs.

Energetic Particles / Solar Radiation: High energy proton flux should gradually decline to background levels by day 2 (24 July), after the recent S1/Minor Storm. Slight Chance of rising above the S1/Minor Storm threshold in response to any notable flares - perhaps now increasingly likely from AR3762 in the southeast as it tracks westwards.

High energy electron flux is expected to remain at Normal Background levels initially, however confidence decreases into the second half of the UTC working week given inbound CMEs. There is perhaps an eventual Slight Chance of Active 24-hour integrated fluence.

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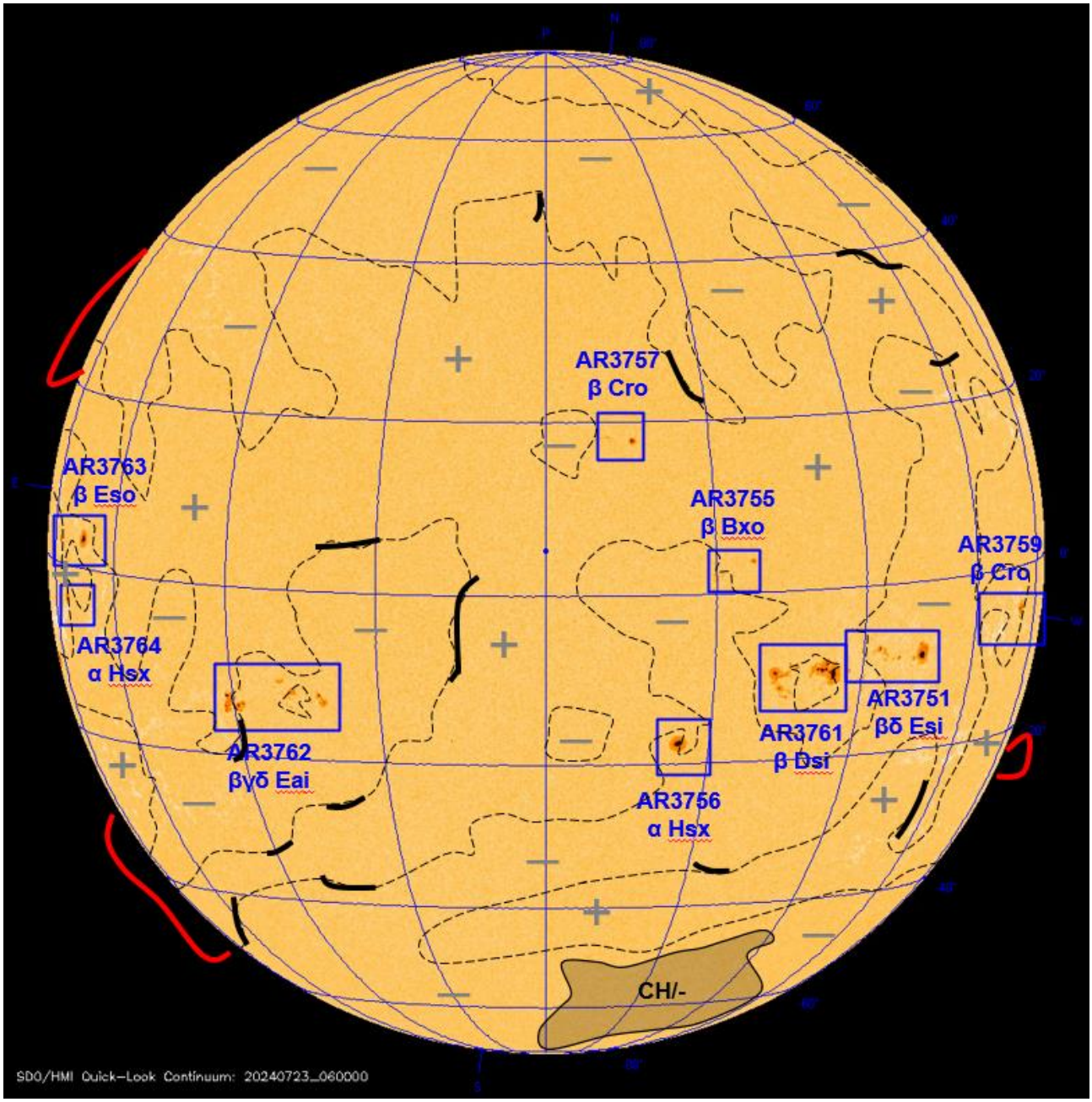
Figure 1. Solar Analysis Valid 23/0600 UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

No fast winds feature in the forecast period, however there are now up to two CMEs.

The first CME - a south-central filament eruption that left the Sun on Friday 19 July - which was due to arrive during the early hours of the current UTC day (23 July), although no evidence of its arrival in solar wind parameters. If it does arrive, it may bring the Chance of Unsettled or Active intervals, with a Slight Chance of G1/Minor Storm. Later the arrival, the weaker this event is likely to be, or the CME may miss Earth.

Secondly, a filament lift-off was observed at 21/1630 UTC. The ejecta was soon followed by a full halo CME on Lasco coronagraph imagery. An Earth-directed CME may arrive either late in the current UTC day (23 July), or more likely during the early hours UTC of 24 July. This brings with it a Likely G2, and a Chance of G3 - the peak risk for the four-day period as a whole.

MOSWOC Enlil modelling currently treats the two inbound CMEs as distinct entities, however there is a small chance that the two agglomerate into one combined arrival, which would tend to favour the G3 outcome if they arrive on the earlier end of forecast expectations. The most likely case remains for separate events however, with the second almost certainly the larger of the two. Geomagnetic activity should begin to wane into day 3, Thursday 25 July, with Quiet conditions likely to see out the current UTC working week, barring new emissions perhaps from AR3762 in particular given its approach to centre-disc by this time.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	50	70	20	1
Strong	G3	No	10	30	1	1
Severe	G4	No	1	2	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
20/0400	Partial	Filament Eruption	S-Centre	615 km/s	23/0800 UTC +/- 9 hours	Northern portion of filament eruption, second of the two.
21/1629	Full	Filament lift-off	NE	1050 km/s	24/0300 UTC +/- 9 hours	Low confidence

Figure 2: Latest available MOSWOC Enlil and ensemble, badge time 23/0600UTC. The first CME from the 19th July is currently overdue. The second and larger CME is expected to arrive early on 24th July, as shown in the image below.

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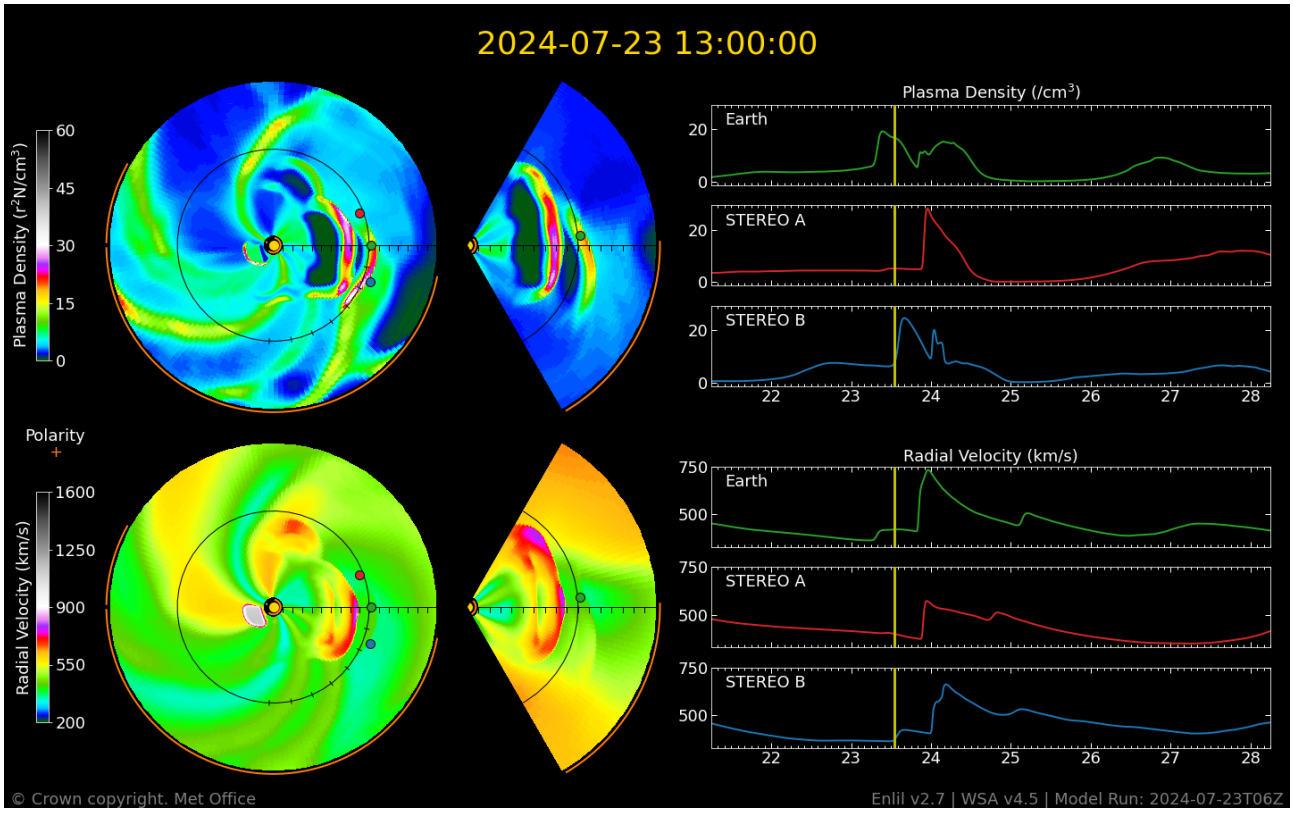

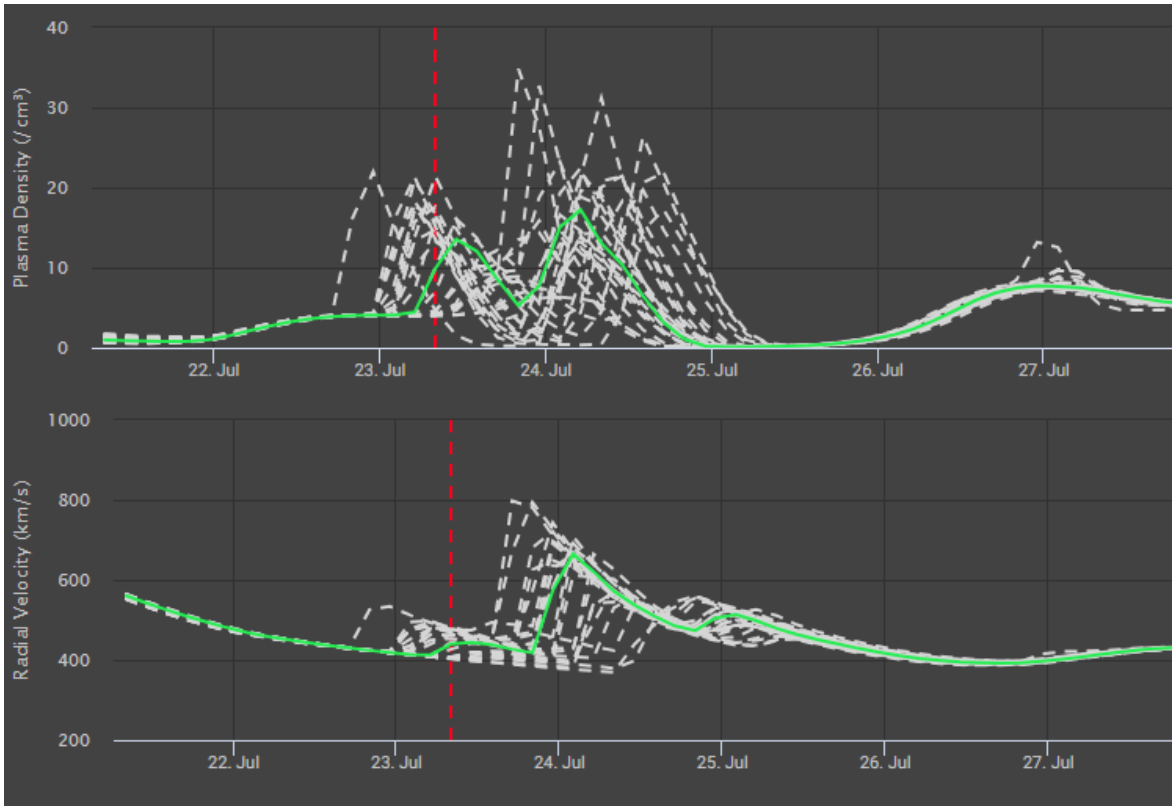

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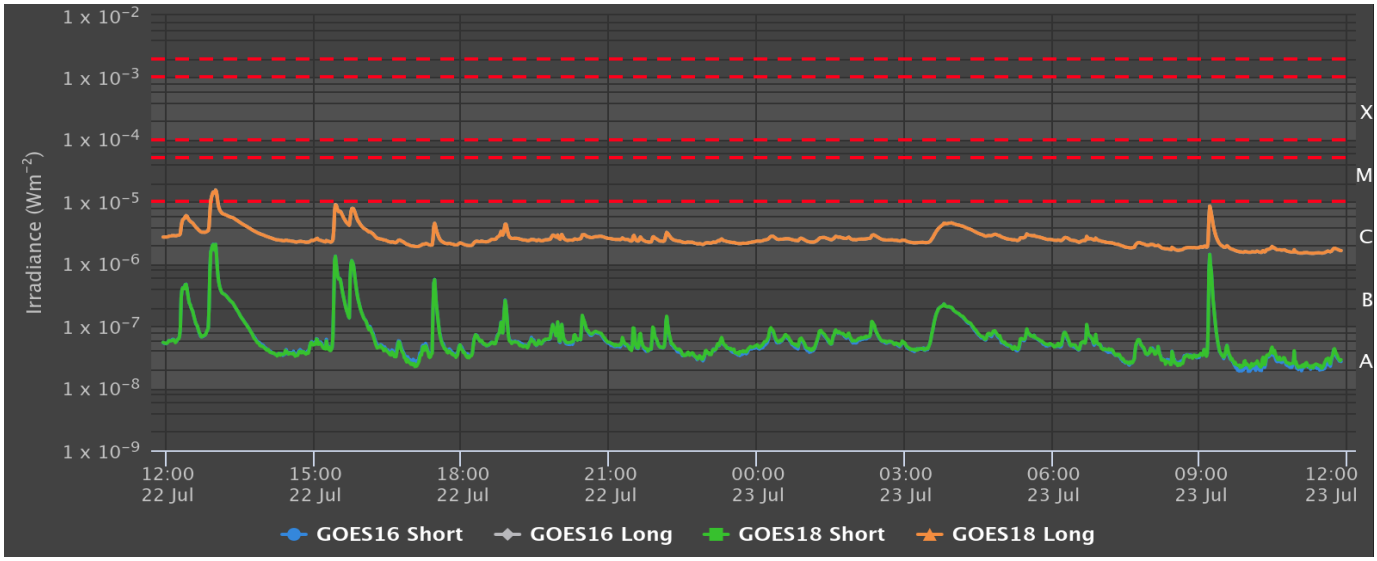
Radio Blackouts - X-Ray Flares:
Given a probable similar lack of arriving regions, the current crop of sunspot regions are likely to largely survive the whole four-day period, and daily risks of M and X class activity are therefore held constant through the period.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	Yes	60	60	60	60
Very Active	R3 to R5 X Class	No	5	5	5	5

Figure 3: GOES-18 X Ray Flux trace.



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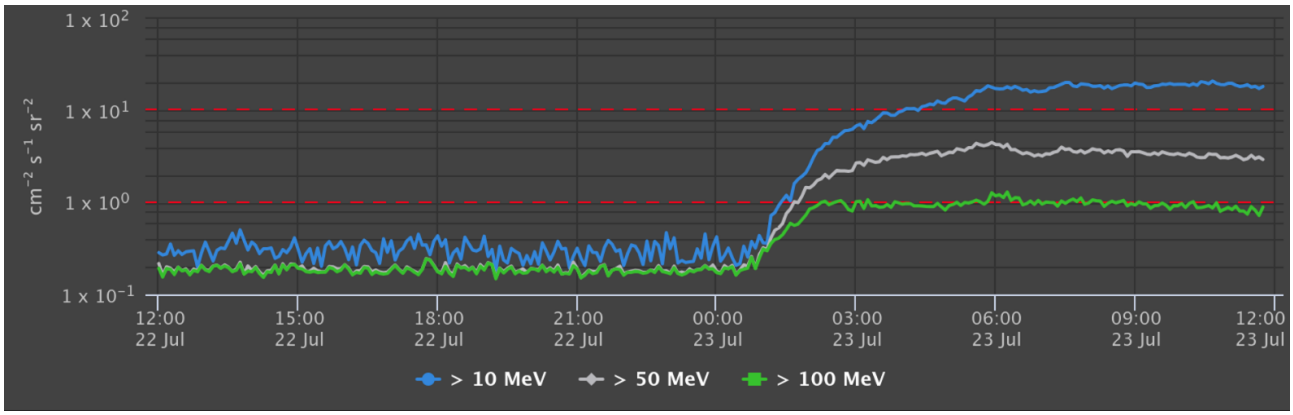
Solar Radiation Storms - (High Energy Protons):
GOES18 proton flux showed a rapid rise from 23/0100UTC with the 10MeV and 100MeV threshold being reached. This was in response to a very large full halo CME, which occurred on the far-side of the Sun. The S1 Minor storm is currently on-going, with the 100MeV showing a gradual decline, although the 10MeV will probably remain above the S1 threshold for much of the UTC day, before a gradual decline to background levels.

There is a slight chance of further S1 events over time as some of the more complex sunspot groups travel ever-westward, with some evidence of enhancement in the past 24 hours.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	Yes	99	20	15	15
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

Figure 4: GOES-18 Proton Flux showing the current S1 radiation storm, which is on-going, which was a respond to the full-halo CME on the far-side of the Sun early on the current UTC day.



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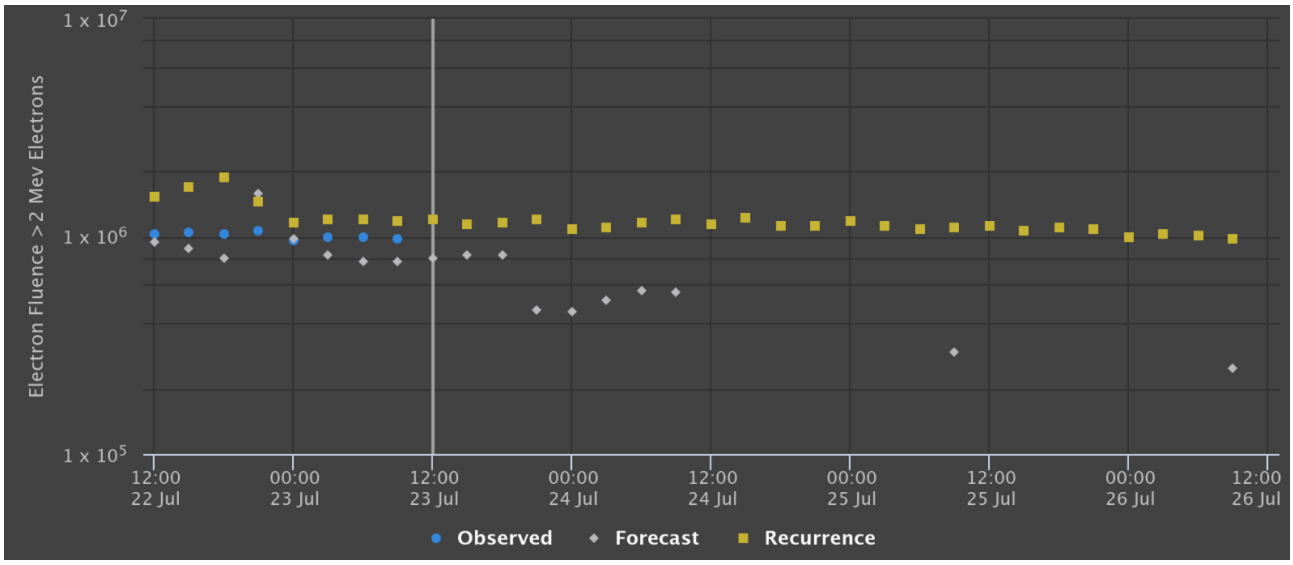
High Energy Electrons Event (≥ 2MeV):
The high energy electron flux as observed by GOES16 is currently at Normal Background and is expected to persist at this level initially. Persistence methods and MOSWOC REFM are not expected to offer a useful steer to eventual fluence levels in the period, owing to the dominance of CMEs in the forecast. On balance, confidence decreases sharply through midweek in current Background levels being maintained, with an eventual rising Slight Chance of Active later in the UTC week once geomagnetic activity wanes.

GEO Electron Environment Probability (Exceedance)	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ 2 MeV ≥ $1x10^8$**	No	1	1	5	10
Very Active	**≥ 2 MeV ≥ $1x10^9$**	No	1	1	1	1

Figure 5: MOSWOC REFM electron fluence.



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